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Title:

An integrated sensor board for real-time optimization of the electrical settings of a microbial electrolysis cell

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Abstract:

1. Introduction

Microbial electrolysis cells (MECs) recover energy from wastewater by hydrogen production. Although state-of-the art shows the optimal electrical settings comprise a trade-off between H_2 enthalpy and applied power, there is no device to track this criterion [1]. Therefore, MECs are controlled with a fixed potential, manually tuned for the particular operating condition using expensive lab equipment [2]. This work presents a programmable, multichannel, low-cost (€200) integrated sensor board to, in real-time and automatically, derive the optimal electrical settings of any MEC.

2. Methods

The board contains six 16bit, ±20mA, current sources, each driving a working electrode and eight 16bit, ±2.5V, voltage measurements, six connected to the working electrodes, and two to the reference electrodes (Fig. 1). These channels are digitally controlled by a TI C2000 microcontroller using the successive parabolic interpolation algorithm. This algorithm converges the MEC to the extremum of a programmable unimodal gain function, using a minimal amount of measurement and actuation steps.

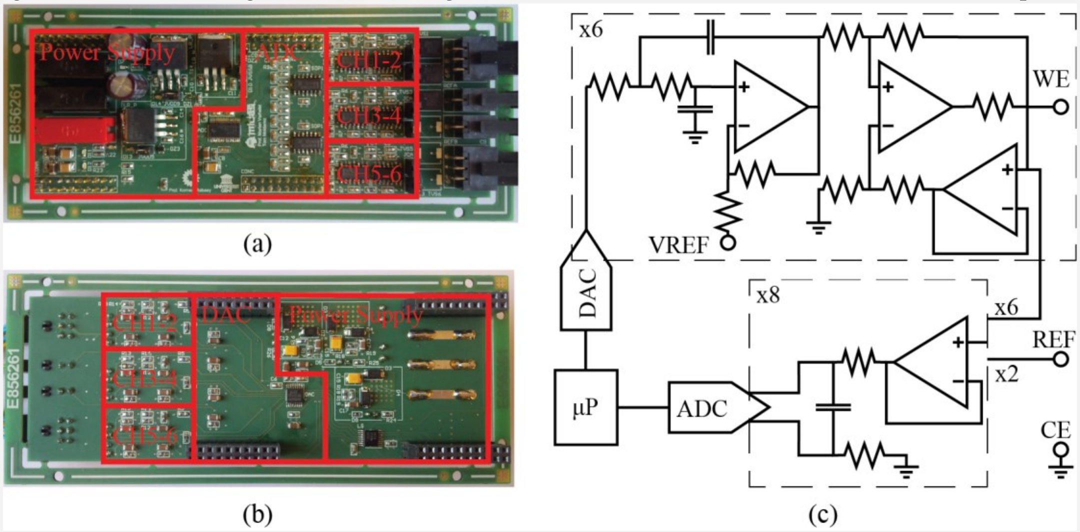

Fig 1 (a) Top view, (b) bottom view and (c) electric circuit schematic of the sensor board.

This is demonstrated through an electrochemical experiment, executed with a mixed 10mM hexacyanoferrate(II) solution. A second, bioelectrochemical, experiment is performed with electroactive biofilms, formed with a mixed culture inoculum from a continuous, acetate-fed MEC.

3. Results

The algorithm is executed three times. Before and after these runs, the true extremum is derived based on the measured polarization curves. Convergence to <2% occurs in 8 steps for the electrochemical experiment (Fig. 2a) and to <4% in 9 steps for the bioelectrochemical experiment (Fig. 2b).

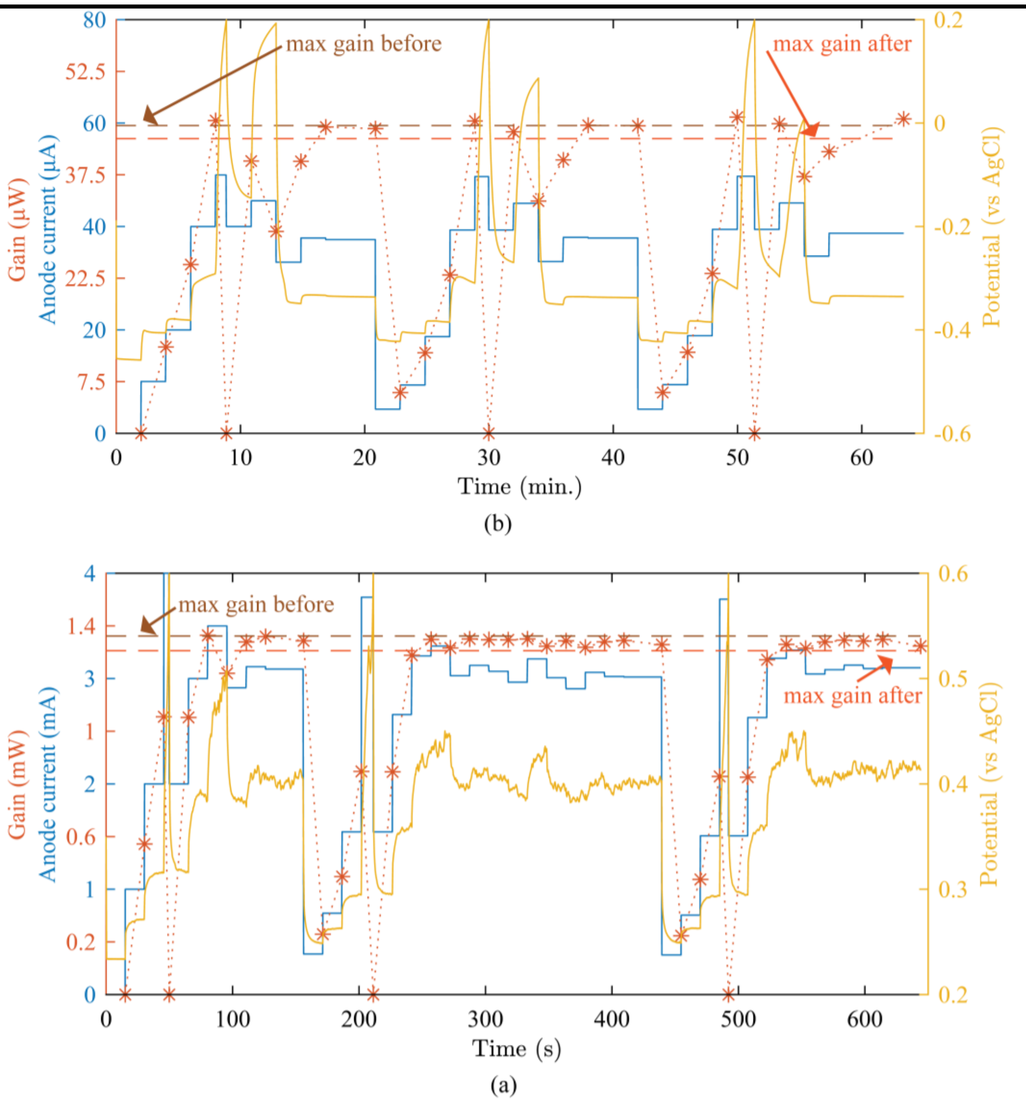

Fig 2 (a) The hexacyanoferrate(II) experiment and (b) the bioreactor experiment. The current is indicated in blue, the potential vs. Ag-AgCl in yellow and the gain function in red. The dashed lines show the true extremum measured before and after each experiment.

4. Discussion

The proposed sensor board derives accurately and automatically the optimal electrical settings irrespective of the given MEC condition. This is beneficial both in a research context as it resolves the manually tuning of the electrical settings for newly envisioned bioreactors as well as in an industrial context for which typically the influent composition varies over time.

[1] R. P. Pinto et al., *J. Process Control*, vol 22, pp. 1079-1086, May 2012
[2] A. Escapa et al, *Renewable and Sustainable Energy Reviews*, vol 55, pp. 942-956, March 2016